EXHAUSTION

White Paper
January 2024

The costs of climate change are high, and so would be the expected socio-economic benefits of effective adaptation and mitigation of climate change.

Effective adaptation and mitigation can reduce the socio-economic costs of climate change

- Heat stress decreases labour productivity and increases the costs of healthcare, even in countries not normally associated with high temperatures (UK and Norway), as indicated by our empirical analysis.
- In the coming decades, and especially for the most extreme heatwave years, the number of cardio-pulmonary disease (CPD) fatalities during hot summers is predicted to be thousands across the European countries analysed (EU27, EEA, west-Balkan, UK and Türkiye), leading to large welfare costs, when assessed by the OECD methodology for valuing statistical lives. Over the next decade, EU27 heat-related CPD fatalities are projected to increase up to 19,000 per year - a doubling of 1990 levels.
- In a broader, macroeconomic context, our further modelling shows that the associated health effects will lead to an increase in unemployment, which in turn affects international trade and a country's gross domestic product (GDP). These impacts are expected to vary across countries. Out of the three countries studied, Italy is, for example, projected to face the highest rise in unemployment; the UK is likely to encounter the most significant price increase; and Norway may suffer the largest GDP loss.

Research findings

Our research examines the socio-economic costs of climate-driven health effects. We analyze historical data to assess how temperature variations affect labour productivity and healthcare expenditures.

Incorporating these findings, we use microeconomic and macroeconomic models to understand the broader socio-economic impacts, highlighting the urgent need to address these environmental challenges (see Figure 1).

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The EXHAUSTION Project estimates the change in cardiopulmonary mortality and morbidity due to extreme heat and air pollution (including from wildfires) under selected climate scenarios, calculates the associated costs, and identifies effective strategies for minimizing adverse impacts.

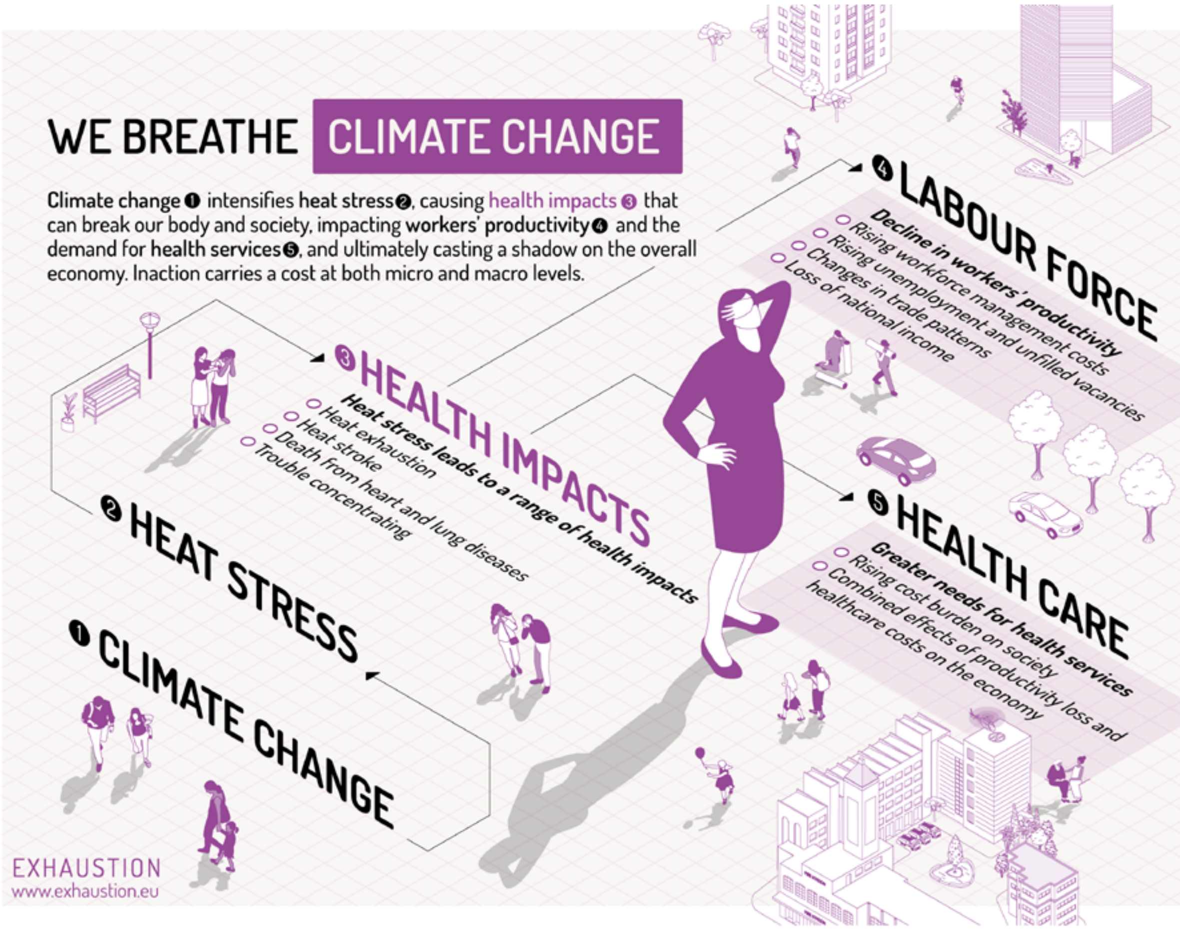

Figure 1: The cost of inaction. Climate change intensifies heat stress, causing health impacts that can break our body and society, impacting workers' productivity and the demand for health services, and ultimately casting a shadow on the overall economy. Inaction carries a cost at both micro and macro levels.

Empirical analysis of the economic consequences of high temperatures

(1) Impact of heat stress on labour productivity in the UK

One part of the empirical analysis uses UK (esp. England & Wales) household panel survey data about individuals' health status and socio-economic characteristics to assess the impact of temperature on labour productivity. In a high-income country with temperate climate, heat-related productivity losses may mostly occur through reduced performance at work, which is hard to measure and may thus get under the radar. We use self-reports of recent under-performance at work related to physical health ('presenteeism' – working while sick).

Our findings show that, in England and Wales between 2010 and 2019, exposure to heat is associated with a greater probability of reporting presenteeism. Each additional day of heat exposure, variously adjusted for its severity, was associated with up to 1.5- and 2.5-times higher incidence of presenteeism in a 4-weeks retrospective period. However, this effect varied across groups. It is more precisely estimated for women, and entirely concentrated in jobs with low physical demands.

(2) Health care costs attributable to heart- and lung diseases in Norway

We also conducted an empirical study in Norway to estimate the direct health care costs from heart- and lung disease (also called cardiopulmonary disease - CPD) using data from the Norwegian Patient Registry (37 000 participants) and assess how ambient air temperature exposure impacts these costs. The association of sociodemographic factors, such as sex, age, education, and income were also assessed.

Our findings indicate that as temperature changes, health care costs attributable to heart and lung diseases also change, but not in a simple, straight-line pattern. We also find that cold temperatures contribute to healthcare costs in Norway. Moreover, we see that there are increased costs for heart and lung diseases associated with the elderly and female participants, thus indicating that healthcare policies need to take these critical vulnerability factors into account.

Modelling heat-related deaths and associated welfare costs

Our modelling shows the highest numbers of heat-related heart- and lung fatalities will occur in Italy, followed by Türkiye, Spain, Romania, Greece and Hungary. We expect annual incidence within the next 25 years to exceed 25 per 100,000 persons in about 25 regions of the Balkans and Hungary (see Figure 2). The EU27 annual average total will more than double from 8,700 heat-related premature CPD fatalities in 1990 to 19,000 by mid-century – peaking up to about 25,000 when considering the hottest decadal heatwave years across regions.

For the hottest years, EU27 costs are found to triple relative to present annual averages (2015-22), while they will quadruple for west-Balkan and Türkiye (see Table 1). This relies on the OECD methodology for valuing statistical lives. Average annual costs during 2015-22 to EU27 at €25.6-27 billion from heat-related Cardio Pulmonary Disease fatalities are well above the European Environment Agency's estimate of about €16 billion covering all extreme weather damage costs for the same period. Measured against GDP there will be large variations, with average annual costs to EU27 at 0,6%, while most west-Balkan countries will exceed 1%.

However, due to the interactive effects of heat and air pollution (see White paper chapter 1), fatalities due to heart and lung diseases and associated costs can be reduced by aiming for adaptation measures that reduce particulate air pollution ($PM_{2.5}$) to levels recommended by the WHO Air Quality Guidelines. The largest reductions, up to 50%, would occur in west-Balkan countries, while the average annual reduction in Balkan and Mediterranean countries, including Türkiye, could be 30%. With today's levels of air pollution maintained, the number of CPD fatalities over the next 25 years would be about 45% higher (about 150,000 cases) than with an abatement strategy for adaptation via air pollution abatement.

Modelling macroeconomic effects

The microeconomic approach used to assess the direct and immediate costs of health effects due to climate change in all European countries is based on the more immediate, effects, meaning that possible further repercussions on the economy ('market effects') are disregarded. To address consequences of these market effects, we estimate the impacts of health effects on the supply of labour and the demand for health services in UK, Italy, and Norway.

These have been integrated in a global macroeconomic model, which describes how economic agents adapt to these changes, resulting in ripple effects across the markets throughout the entire economy, shedding light on a more comprehensive perspective of health-related costs. The socioeconomic impacts of health effects due to climate change are complicated and differ by country (see Figure 3):

- The declined labour productivity will lead to a substantial increase in unemployment and a reduction in job vacancies across all three represented countries. Out of the three countries studies, the UK appears to be the most affected in this regard. Additionally, Italy's significant heat -related productivity loss will greatly increase the labour costs and reduce total production in the country.

- Climate change is expected to reduce GDP for all countries, with Italy experiencing a more modest GDP decline due to increased trade and consumption goods prices. By contrast, Norway and the UK will face more significant declines in GDP, primarily driven by the lowered consumption and augmented savings.

- The trade effects play important roles on the heterogeneous effects on GDP. The trade balance is expected to increase sharply in Italy, primarily attributed to the reduction in the price of imported foreign goods and a rise in the prices of domestic goods. Conversely, in Norway and the UK, the trade balance is projected to decline, owing to higher domestic prices and a comparative disadvantage in domestic products competing with foreign products.

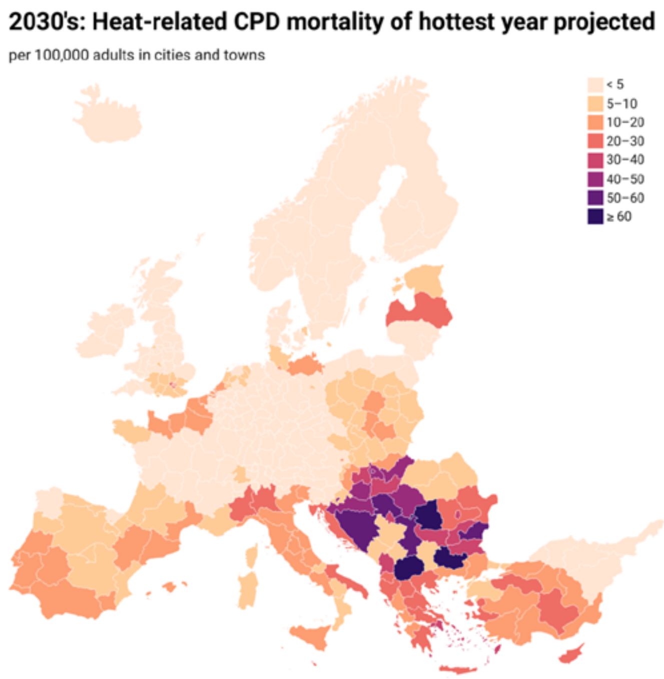

Figure 2: Heatwave scenario 2030s (specific year varies by region): Heat-related CPD deaths per 100,000 adults in cities and towns of single hottest year during a 10-year period projected in the 'Middle of the road'-scenario (SSP2)

Table 1: Annual welfare economic costs of heat-related CPD fatalities at country level (M€)

Year	2015-22	2030-34	2045-49	Max 2030s*	Max 2040s*
Country					
Cyprus (EU)	315	409	483	484	667
Greece (EU)	1,788	2,825	3,723	4,145	4,887
Italy (EU)	10,126	14,243	14,725	17,888	21,563
Malta (EU)	115	156	197	208	265
Portugal (EU)	253	299	435	1,072	1,277
Spain (EU)	2,736	3,413	3,978	5,936	5,782
Türkiye	3,870	7,422	10,980	11,145	16,206
Albania	244	442	492	527	683
Bosnia#	248	488	518	804	1,165
Bulgaria (EU)	912	1,276	1,626	2.004	2,527
Croatia (EU)	565	874	932	1,145	1,577
Kosovo#	16	30	33	50	63
Montenegro	20	46	50	63	79
N Macedonia	120	281	390	501	499
Romania (EU)	2,148	3,715	4,304	5,683	7,150
Serbia	742	1,566	1,608	2,396	3,097
Austria (EU)	401	662	712	922	1,162
Czechia (EU)	191	384	464	703	819
Hungary (EU)	930	1,831	2,077	3,246	3,843
Lithuania (EU)	29	42	86	112	145
Poland (EU)	1,032	2,320	3,259	4,968	5,710
Slovakia (EU)	117	229	275	421	452
Slovenia (EU)	41	74	75	124	145
Belgium (EU)	217	425	420	845	746
France (EU)	1,259	2,160	1,882	4,739	4,563
Germany (EU)	1,671	3,084	3,942	5,678	7,334
Liechtenstein	0	<1	<1	<1	<1
Luxembourg (EU)	2	4	4	7	8
Netherlands (EU)	906	1,832	2,505	3,490	4,524
Switzerland	350	499	534	812	998
Denmark (EU)	61	158	450	664	1,211
Estonia (EU)	52	63	115	184	248
Finland (EU)	76	49	192	163	426
Iceland	0	0	0	0	0
Ireland (EU)	0	10	0	99	4
Latvia (EU)	163	231	402	740	793
Norway	2	13	110	77	314
Sweden (EU)	96	184	484	745	1,187
UK	1,717	3,494	2,391	14,419	9,635
EU27 sum	25,639	40,078	46,813	65,269	77,439
EU27 same VSL	27,152	37,268	40,979	60,643	67,373
All countries, sum	**33,533**	**55,235**	**64,852**	**97,209**	**111,757**

#Imputed CDD

*Sum of the maximum decadal heat spell costs of all individual NUTS2 regions, notwithstanding specific year

Figure 3: Projected economic impacts (%) by the year 2050 under the Regional Rivalry scenario, SSP3.

Key policy recommendations

- Due to the interactive effects of heat and air pollution ($PM_{2.5}$) as estimated for major cities in the above countries, a suitable measure for adaptation is to target reductions in such air pollution, and the analysis estimates the socio-economic cost savings resulting from the associated reductions in summer mortality for heart- and lung diseases, which amount to 30% for Mediterranean and Balkan countries.

- Emphasizing a macroeconomic approach: A systematic macroeconomic approach is highly recommended when evaluating the broad socio-economic impacts of climate change, with particular attention to the health effects.

- Highlighting differences in impact across countries: The study shows diverse and uneven socio-economic impacts of health effects due to climate change among targeted countries. This highlights potential distributional effects within Europe and the necessity of tailored policy measures that recognize the unique challenges faced by each country to achieve efficiency and equity.

Worker in construction site a hot day in central Athens, Greece. Photo: Istockphoto/Alexandros Michailidis

Key research recommendations

More tailored surveys are needed to better estimate the effects of heat stress on the labour force/workforce.

- Heatwaves are sparse in time and space: thus, population studies require a larger sample of affected individuals, combined with strategies for fast-rollout of data collection.
- Short-term individual output is hard to measure in high-income labour markets. Self-reports are useful but must provide simple quantifiable information to estimate losses. These can be complemented with statistics on daily and hourly absenteeism.
- Research should consider more fully the role of potential physiological factors affecting thermoregulation; individual habits and investments; buildings and the natural environment in the community (green spaces).
- Ideally, there should be linkable data on local climate, infrastructure and policies.

Long-term solutions include occupational heat stress surveillance, which would require, e.g.:

- Routine surveys of firms and workers during/immediately after a heat spell.
- Ad hoc surveys in vulnerable occupations (for example food delivery services and construction workplaces)
- The inclusion of evidence-based legislation and guidelines on compensation, days off, breaks, cooling, in cooperation with relevant actors (trade unions, occupational health workers etc.).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 820655.